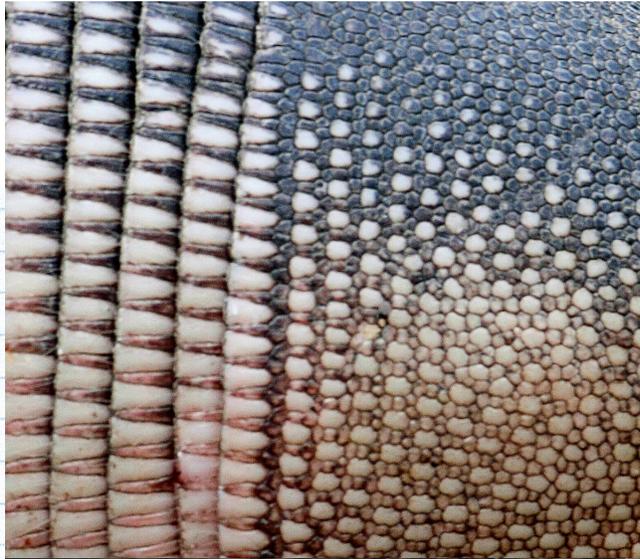


# SCIENCE FAIR CENTRAL

## Maker Corner Activity



## ARMADILLO ARCHITECTURE

Grades 6-8

# MAKE. CREATE. EXPLORE.

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Using natural inspiration to solve engineering and design challenges is called biomimicry.

## Overview

### Nature has a lot to teach us.

The processes of change and natural selection have refined plants and animals into elegant and efficient organisms. Many advances in science and technology stem from natural inspiration. For instance, scientists are making wind power more efficient by designing turbines that mimic the aerodynamic flippers of a humpback whale. This approach of using natural inspiration to solve engineering and design challenges is called biomimicry.<sup>1</sup>

**This activity focuses on** the “Creating or Prototyping” stage of the Engineering Design Cycle. In this activity, students will learn about the efficient and lightweight shell of an armadillo. Students will then apply these advantageous adaptations to their own architectural model using a variety of different materials.

Students will look to the lightweight and dexterous shell of an armadillo to create a unique solution to an architectural challenge.

This activity focuses on the **Creating or Prototyping** stage of the Engineering Design Cycle.

### Engineering Design Cycle

- Defining the Problem
- Designing Solutions
- **Creating or Prototyping**
- Refine or Improve
- Communicating Results

## Objectives

### Students will be able to:

- **Analyze** the qualities and design of an armadillo shell,
- **Apply** that knowledge to the field of architecture and
- **Create** an original prototype that blends the effective design of an armadillo shell and sound principles of architectural design.



# Armor keeps armadillos safe from predators.

## Materials

- Rubric student handout
- Graph paper
- Pencil
- Construction paper
- 2 sheets of 2 in. thick multipurpose foam
- (1) can of spray adhesive
- (1) sheet of ¼ inch thick 2x2' plywood
- (1) Xacto knife
- (1) sheet of 1/16 inch thick 4x8' plastic paneling
- (1) pencil compass
- (1) pair of craft shears
- (1) bottle of Gorilla Glue
- (1) roll of duct tape
- (1) can of insulating foam sealant



## Have you ever wondered . . .

### Why the armadillo evolved to have its unique, armor-like shell?

Glyptodonts were ancient ancestors of our modern armadillos. These large, bony mammals were covered in a hard shell (called a carapace) and even had a club-like tail! The glyptodonts' armor protected them from fierce predators like saber-toothed cats.<sup>2</sup> The glyptodonts evolved over millions of years, losing their club tails and shrinking in size. There are now 21 different species of armadillos that relate back to glyptodonts. Each modern armadillo species has its own carapace made of overlapping plates of bone. This armor keeps the armadillos safe from predators and cools them down in hot environments.<sup>3</sup>

### How we can make the buildings of the future more secure and eco-friendly?

The armadillo's strong, lightweight shell is a great inspiration for architectural design. Architects in Singapore looked to the armadillo's armor to solve a design challenge—they needed to build a family home built just above a noisy, busy freeway. The home's overlapping shell design keeps out traffic noise, allows natural light to shine through and provides the occupants with privacy.<sup>4</sup>

**Architects in Singapore looked to the armadillo's armor to solve a design challenge!**



# Make connections!

## How does this connect to students?

Sometimes the best solutions to design challenges come from Mother Nature! For instance, scientists are looking to dolphins—underwater communications experts—to teach us how to transmit emergency signals that alert citizens at the threat of a tsunami.<sup>1</sup>

## How does this connect to careers?

**Architect**—Architects plan and design the spaces we use, such as homes, offices, libraries, and stadiums.<sup>5</sup>

**Materials Engineers**—Materials engineers develop the materials we use, impacting everything from clothing to smartphones.<sup>6</sup>

**Civil Engineers**—Civil engineers design structurally sound buildings, roads and bridges.<sup>7</sup>

**Drafters**—Drafters convert the ideas of architects into technical drawings that engineers and builders use in construction.<sup>8</sup>

## How does this connect to our world?

As our environment changes, humans are at increased risk for threats like diseases and natural disasters. Animals and plants have evolved over millions of years, adapting to the same dangers that our society must face. We can look to these savvy specimens to develop products and practices that help humans survive.



## Blueprint for Discovery

### 1. Share the following scenario with students:

*Imagine you are an architect that is famous for using biomimicry to solve design challenges. A client in Dallas, Texas has hired you to build a Hall of Fame Museum. The Hall of Fame Museum will be located in a very arid section of the city where there is little tree cover. The client wants a design that will maximize energy efficiency by keeping the building cool. The Hall of Fame Museum will face a busy highway, and the client wants a design that will insulate the building from the noise of traffic.*



You think that the following characteristics of an armadillo's shell should be replicated in order to meet the client's goals:

1. Reflective armor that shields the building from heat.
2. Lightweight building materials that protect from the elements.
3. Overlapping plates that block out sound but allow for natural light.

Your task is to create a model of the Hall of Fame Museum to show your client. The model must be no bigger than 2x2' in size.

**Teacher note:** If time allows, students can [read more](#) about the armadillo and identify characteristics that could be replicated in an architectural design.

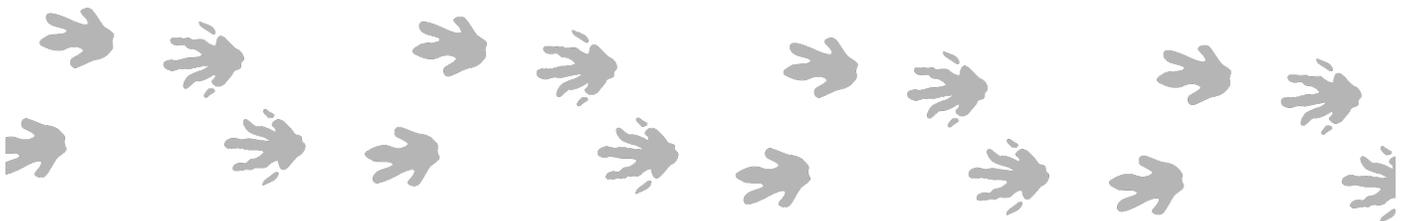
**2. Ask students to respond** to the following questions on a blank sheet of paper:

- What features does the *Hall of Fame Museum* need to have?
- How will you incorporate design elements that mimic an armadillo shell?

**3. Display the materials to the class.** The materials should be ones that students can later select to design their structure. It might include materials such as foam, adhesive, plastic paneling, construction paper, and plywood. Provide 5 minutes for students to explore the items. Ask students to brainstorm how they have observed the different materials used.

**4. Guide students to share** out which materials might be best to construct a model of their structure that is:

- Reflective
- Lightweight
- Blocks out sound
- Allows for natural light



**Reflection occurs when light bounces off objects.**



**5. Direct students to sketch their design** on a sheet of graph paper. Remind students that the model must be 2x2' in size, and that 2x2 is a perfect square because all of the sides will be the same length. To find the area of a square, multiply the length of a side times four.

**Ask students:**

- What is the area of your model?
- How can you draw your design to scale so that you can measure your materials appropriately?

**Hint:**

- Create a key on your graph paper—every foot of space will be represented by ten blocks.
- Draw a square on your graph paper that is twenty blocks across and twenty blocks high.
- Use the square you have drawn to sketch your design.

**6. Once students have created a design, guide students to select materials** to construct their model. They should use the plywood as a base and begin construction.

**7. When models are complete, ask students to display their design** at a desk space or around the room. Distribute the *Rubric student handout* and ask students to cut it into thirds. Each student should visit at least three other projects and complete the rubric. They will leave their feedback at the projects they visit.

**8. Invite students review the feedback left at their project.** Then, ask students to summarize evidence from their own reflection and the *Rubric student handout* to respond to the following questions:

- What were the strongest features of your design?
- What were the weaknesses of your design?
- How would you re-design your model after reviewing your feedback?

## Take Action

**Want to learn more about biomimicry and architecture?**

**Check out the following activities!**

- [Build a simple vibrobot that looks like a spider](#)
- [Engineer a robotic hand using drinking straws](#)
- [Check out the Biomimicry Institute for more examples of biomimicry innovations](#)



# National Standards

## Science

[Next Generation Science Standards](#)

### **K-ESS3-1 Earth and Human Activity**

Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live.

### **4-LS1-1 From Molecules to Organisms: Structures and Processes**

Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

### **1-LS1-1 From Molecules to Organisms: Structures and Processes**

Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.

### **2-PS1-2 Matter and Its Interactions**

Analyze data obtained from testing different materials to determine which materials have the properties that are best suited for an intended purpose.

### **3-ESS3-1 Earth and Human Activity**

Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.

### **3-5-ETS1-1 Engineering Design**

Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.

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## Technology Education

[International Technology and Engineering Educators Association](#)

**Students will develop an understanding of Design. This includes knowing about:**

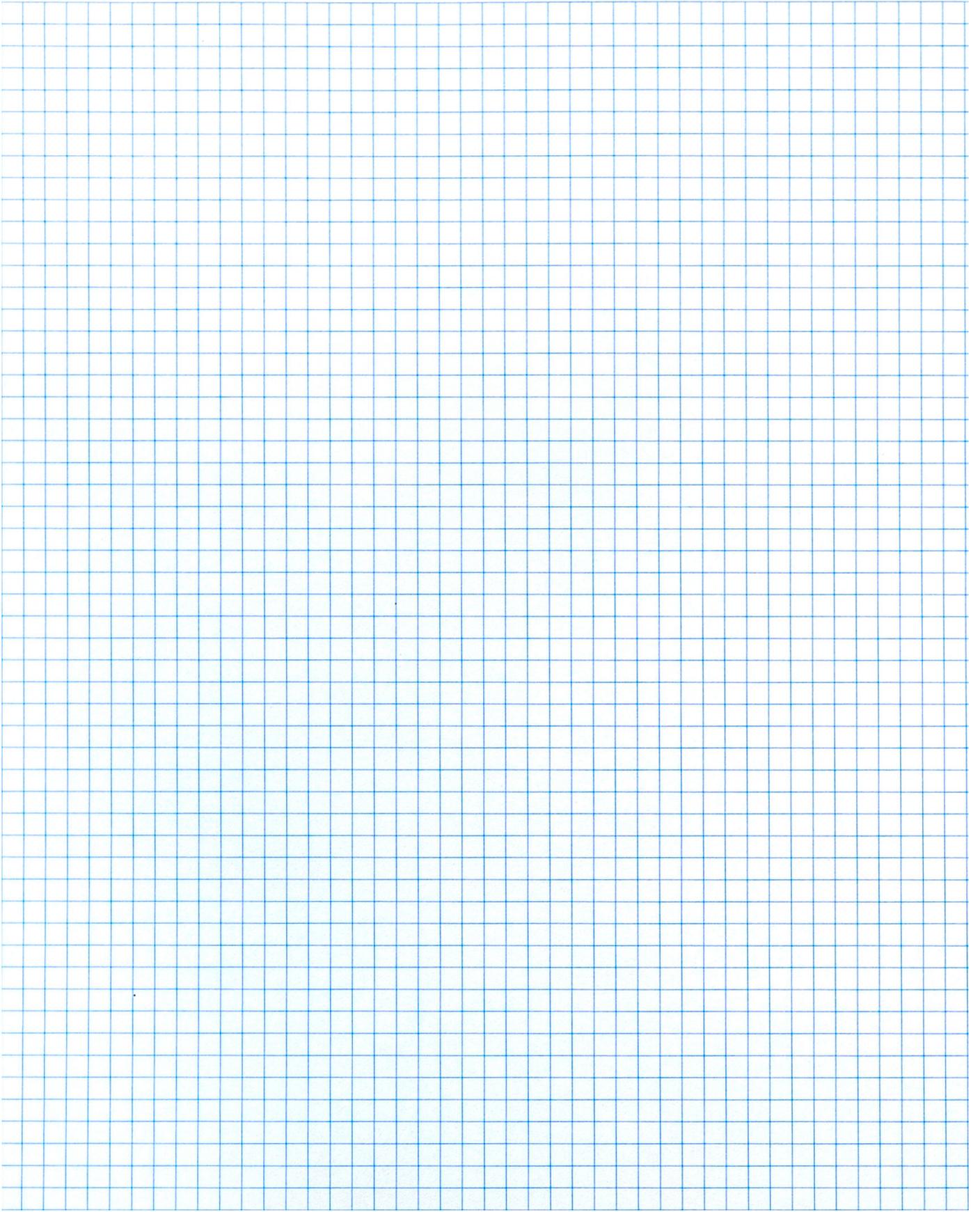
- Engineering design
- The attributes of design
- The role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving





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<https://biomimicry.org/what-is-biomimicry/>
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6. U.S. Bureau of Labor Statistics. Occupational Outlook Handbook: Materials Engineers. December 17, 2015.  
<https://www.bls.gov/ooh/architecture-and-engineering/materials-engineers.htm>
7. U.S. Bureau of Labor Statistics. Occupational Outlook Handbook: Civil Engineers. December 17, 2015.  
<https://www.bls.gov/ooh/architecture-and-engineering/civil-engineers.htm>
8. U.S. Bureau of Labor Statistics. Occupational Outlook Handbook: Drafters. December 17, 2015.  
<https://www.bls.gov/ooh/architecture-and-engineering/drafters.htm>



# Rubric

Rate different groups on the following categories.

Group: \_\_\_\_\_

Need/Concern	No	Somewhat	Yes
Does the design have a reflective element to shield the building from heat?			
Does the design use lightweight building materials that can still protect it from weather?			
Does the design have a feature that could help block sound?			
Does the design have a feature that allows for natural light?			
What features are most strongly inspired by the armadillo shell?			

Group: \_\_\_\_\_

Need/Concern	No	Somewhat	Yes
Does the design have a reflective element to shield the building from heat?			
Does the design use lightweight building materials that can still protect it from weather?			
Does the design have a feature that could help block sound?			
Does the design have a feature that allows for natural light?			
What features are most strongly inspired by the armadillo shell?			

Group: \_\_\_\_\_

Need/Concern	No	Somewhat	Yes
Does the design have a reflective element to shield the building from heat?			
Does the design use lightweight building materials that can still protect it from weather?			
Does the design have a feature that could help block sound?			
Does the design have a feature that allows for natural light?			
What features are most strongly inspired by the armadillo shell?			

